Master’s specialisation in Neurophysics

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https://www.ru.nl/opleidingen/master/neurophysics

Student: Lennaert van der Molen

change perspective
Master’s specialisation in Neurophysics

This specialisation is part of the Master’s programme(s) in Physics and Astronomy

It offers a flexible and interdisciplinary programme, which challenges you to unravel the workings of the most complex system known to us, the human and animal brain, using experimental, theoretical, and computational methods from the natural sciences.

Focus:
This a unique program in the Netherlands. We cover the full spectrum from behavioural studies with human subjects (psychophysics), computational studies of advanced brain models (neuroinformatics, computational neuroscience), to theoretical studies on intelligent systems and behaviour (machine learning, robotics, artificial intelligence, data science), and electrophysiological studies (the ‘hardware’)

For whom:
Students with a bachelor diploma in
  Physics, Science, but also
  Biomedical Engineering, Mathematics, or similar
Master’s specialisation in Neurophysics

“To understand ANY information-processing system, it has to be studied at three complementary levels, all equally necessary” (David Marr, ‘82):

• **L1:** What is the function of the system? Why does it do what it does? What benefit does it acquire? Which problem (usually, for survival) does it solve? How does it do it? In Neuroscience, this is the research topic of *Psychophysics (the goal)*

• **L2:** What is the optimal algorithm, computational principle, that underlies the observed behavior? Importantly, how can the system acquire such behavior through unsupervised learning? This is the field of *Computational neuroscience and Machine Learning (the software…)*

• **L3:** How are the algorithm(s) and behaviour(s) implemented in the system? In Neuroscience, this is the topic of *Neurophysiology (the hardware…)*

The Neurophysics specialisation at DCN studies all three levels.
Why study Neurophysics at Radboud University?

• A **multidisciplinary field**, merging neurobiology, physical chemistry, informatics, mathematics, and physics. You become an analytic, independent academic with relevant skills, prepared for near-future technologies (AI, data science, etc.)

• Large **flexibility** in designing your own study program, depending on your personal preferences (more experimental, theoretical, or more neurobiological, biochemical, etc.), through a wide variety of elective courses.

• Possibilities for **external internships**, e.g. at Philips (Brain, Body and Behavior division), several MSE companies, Maartens Kliniek (revalidation), RadboudUmc, but also at the Instituto Técnico Superior in Lisbon (robotics), Western Univ. at London, Ontario, etc. etc..

• Possibility to incorporate a **minor data science** into your master program

• Possibility to obtain a **double master diploma**: in Physics and Astronomy (your principal diploma) and Cognitive Neuroscience (60 ec courses at the CNS master; total 180 ec)
## Curriculum Master’s specialisation in Neurophysics

<table>
<thead>
<tr>
<th>Category</th>
<th>Courses</th>
<th>Credits</th>
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<tbody>
<tr>
<td><strong>Compulsory courses</strong></td>
<td>Physics and Astronomy</td>
<td>7 EC</td>
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<tr>
<td><strong>Compulsory courses</strong></td>
<td>Neurophysics</td>
<td>15 EC</td>
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<tr>
<td><strong>Specialisation electives</strong></td>
<td>*e.g. Computational neuroscience (6 EC), Machine Learning (6 EC),</td>
<td>18 EC</td>
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<td>Quantitative Brain Networks (3 EC), Psychophysics 2 (6 EC)</td>
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<td><strong>Free electives</strong></td>
<td>**e.g. Minor Data Science (20 EC), courses from the CNS master,</td>
<td>20 EC</td>
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<td></td>
<td>other Physics courses (e.g. Computational physics), some bachelor courses</td>
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<tr>
<td><strong>Internship</strong></td>
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<td>60 EC</td>
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*Considerable Freedom*
Compulsory courses Master’s specialisation in Neurophysics

Compulsory Physics courses (7 EC):
Electrodynamics (3 EC), Philosophy (3 EC), Professional Preparation (1 EC)

Compulsory Neurophysics courses (15 EC):

Course 1
Neurobiophysics (6 EC) / Sensory encoding, Neural modelling, Brain and Behaviour

Course 2
Methods in Neuroscience (3 EC) / Modern experimental and data analysis techniques

Course 3
Systematic Review in Neuroscience (6 EC) / Literature study, own topic, report writing
**Minor Computational Data Science (CDS)**

**Mandatory Courses:**
Numerical methods (3ec), Advanced programming (3ec), Machine learning (3ec)

**Electives IMM**
- Quantum chemistry (3ec)
- Quantum dynamics (3ec)
- Molecular modeling (3ec)
- Pattern recognition for Natural science (3ec)

**Electives IMAPP**
- Monte Carlo Techniques (6ec)
- Data analysis (3ec)
- Machine learning in particle physics and astronomy (3ec)
- Astronomical Data analysis and instrumentation (3ec)

**Electives DCN**
- Advanced machine learning (6ec)
- Computational neuroscience (6ec)
- Machine Learning in practice (6ec)
Research Master’s specialisation in Neurophysics

This specialisation is embedded in the Donders Centre for Neuroscience (DCN@FNWI).

Research departments and topics at our Centre

- **Biophysics**: Psychophysics (Van Opstal, Van Wezel, Van Wanrooij, vacancy) Machine Learning, Optimal Control, Data science (Kappen) L1+2
- **Neuroinformatics**: Computational modelling (Tiesinga), Electrophysiological and modelling studies of the memory system (Battaglia). L2+3
- **Neurophysiology**: Neural implementation of sensorimotor behaviors (Celikel, Englitz, Zeldenrust). L2+3
- **Applications**: Sensory and motoric patients (hearing, vision, balance, motoric) Forensic analysis through machine learning (Bonaparte) Bits and Brains (with Solid-State Physics); Human Brain Project. L1+2

Facilities

- Six fully equipped psychophysical labs (visual, auditory, vestibular), EEG/fNIRS lab
- Animal facilities with high data throughput recording systems
- Computer facilities for large-scale computational modelling studies
- The Donders Neuroimaging facilities (MEG, fMRI)
Internships Master’s specialisation in Neurophysics
Relevant departments at Radboud University

Science faculty
• Dept. of Biophysics (Van Opstal, Kappen, Van Wezel, Van Ee, vacancy)
• Dept. of Neuroinformatics (Tiesinga, Battaglia)
• Dept. of Neurophysiology (Celikel, Englitz, Zeldenrust)
• Donders Center for Cognitive Neuroimaging (Norris)

Medical faculty
• Dept. of Cognitive Neuroscience (Goossens)
• Depts. of Otolaryngology (Snik) and Neurology/Clinical Neurophysiology (Bloem)

Social sciences
• Sensorimotor Lab (Medendorp)

Universities abroad (examples)
• Western Univ. in London, Ontario, Brain and Mind Institute (Corneil; systems neuroscience)
• Instituto Técnico Superior de Lisboa (Bernardino; robotics)
• Max Planck Institute in Frankfurt (Fries; primate neurophysiology)

Companies (examples)
• Philips Eindhoven
• Other companies (Artinis (fNIRS), TMSi (EEG), hearing aid/cochlear implant companies)
Admission requirements Master’s specialisation in Neurophysics

You’ll need a Bachelor’s diploma in

- Physics, preferably with a minimum of 9 EC Neuroscience Bachelor courses*
- Science, with 9 ec from *
- Mathematics, with 9 ec from *
- or a related discipline (e.g. (Bio)medical or Electrical Engineering)

And a fluency in both written and spoken English

- A TOEFL score of >575 (paper based) or >232 (computer based) or >90 (internet based)
- An IELTS score of >6.5
- Cambridge Certificate of Advanced English (CAE) or Certificate of Proficiency in English (CPE) with a mark of C or higher

Native speakers of English and students with a Dutch VWO or Bachelor’s diploma don’t need to perform an English test.

*Neurophysics 1 and Neurophysics 2, Psychophysics 1, Introduction Machine Learning (each 3 EC)

(two of these courses may be included in the free electives of the master; prior to the start of the master, where Neurophysics 1 may be done (recommended) as self-study)
Career prospects Master’s specialisation in Neurophysics

Positions of our alumni:

• PhD student in Neuroscience topics, anywhere in the world
• PhD student in other disciplines, e.g. electrical engineering, computational modelling
• Teaching (physics)
• Some stay in academia (postdoc, assistant/associate/full professor)
• Start-up companies (e.g. Orikami, SMART)
• Politics
• Banks (data science)
• Philips (BBB, lighting, …)
• Shell (data science, modelling)
• ASML (control problems)
• TMSi, Artinis, XSense, HOCOMA, Cochlear
  (applied bio-measurement systems/prosthetics)
• Clinical physicist
• Maartenskliniek (revalidation technology)
• ……
Questions, more information?

Coordinator of the Neurophysics specialisation:

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Master’s specialisation in Neurophysics

Lennaert van der Molen
My History

• Bachelor’s degree in Molecular Life Sciences
• Interested in the mathematical framework to describe brain functioning
• Bachelor in Physics
• Courses about Neurosciences most interesting
Nijmegen

- Has a lot to offer culturally
- Not difficult to find a room
Neurophysics

• Broad and extensive offer of neurophysics courses

• Room to focus on what you find interesting
  – In my case, experimental neurophysics and biology

• Interested in doing internship abroad

• Experience with programming not essential
  – You will become proficient